Cumulative impact assessment report by AHEC-IIT Roorkee

A review of the river-ecology aspects

This review is focused on the river-ecology aspects and implications of the Assessment of Cumulative Impact of Hydropower Projects in Alaknanda and Bhagirathi Basins upto Devprayag, by the Alternate Hydropower Energy Centre at IIT Roorkee, for the Ministry of Environment and Forests. This report followed a recommendation by the Forest Advisory committee of the Ministry, that no further approval for the diversion of forest land be accorded to hydropower companies until the cumulative impact of the numerous hydropower projects coming up in the various basins, were assessed. The AHEC-IITR submitted their draft report in March 2011. This was put up on the MoEF website in June 2011.

"We feel that benchmarking the current status of the floodplains with the conditions 10,000 years ago is not reasonable." Alright. How about just 30 years for these two sub-basins? *So in their entire study, they have no benchmark, and no assessment of incremental impact over time at all.*

Scope First of all, this assessment must be understood and acknowledged to be only a partial one, and not the basis for any decisions on hydro-power projects. The AHEC-IITR assessment covers only two upper sub-basins of one tributary of the Ganga, the Alaknanda and the Bhagirathi. The assessment of cumulative impact is premised on the understanding, and backed very substantially by the River Continuum Concept[1], that a river is one entity, from its small tributaries to its estuary. As such, the physical and biological processes initiated in its upper reaches have critical links with the trophic build-up along the entire length of the river, and indeed the oceans they connect with. Rivers are the earth's circulatory systems, and serious disruptions at any point in the cycle, affect the whole.

Sub-basins are just a part of the build-up, and in this case, do not even cover the entire ecological zone of the rhithron (fast flowing, cold waters of the mountain stretch). Therefore, a cumulative impact assessment would rightly require that impacts be assessed along an entire river system (because that is the scale and spread of the impacts), and with the increment of the various human caused impacts; such as fragmentation by blockage and diversion, abstraction for irrigation, for industry, sewage and effluent drainage and so on. While it is understandable that such an assessment may have been too much for AHEC to undertake by itself and in just 6 months, it would have been possible to have multiple competent agencies conduct assessments in different stretches of the Ganga simultaneously. It is only then that it would be possible to understand and co-relate the incremental and cumulative impact of all the actions put together. Partial analysis cannot be the basis for policy or executive decisions. Moreover, all the main recommendations on environmental aspects contain caveats and provisos, and are numbingly equivocal.

However, let us take a closer look at this partial assessment.

In their preambles to the various sections (chapters 6-7 that deal more specifically with the biological aspects), they quote the best definitions that convey well-considered environmental concern. Like "hydrological variability being essential to maintain the health of river" and the need to ensure that "optimum flows" are maintained by hydro-projects "that are compatible with maintaining the integrity of the aquatic environment downstream", and so on. You know they have a comprehensive picture in mind when they specify downstream water-bodies to include "coastal waters, wetlands (mangroves, sea-grass beds, floodplains) and estuaries." They even use words like *integrity.* And then they do the following.

They put paid to the consideration of the increment of "past actions" by placing it in a light where it seems ridiculously excessive, and then dismiss it altogether. On the important issue of baseline conditions for river ecosystems (7.3.2) they quote a study which in a general sense is referring to the changes in flood-plains worldwide due to human occupation, saying that "less than approximately 10% of the original (i.e. 10,000 years ago) floodplains still remain". The IITR study then go on to say that "We feel that benchmarking the current status of the floodplains with the conditions 10,000 years ago is not reasonable." Alright. How about just 30 years for these two sub-basins? *So in their entire study, they have no benchmark, and no assessment of incremental impact over time at all.*

One has to bear in mind that this assessment is likely to be held as a template for methodology for other assessments across the country. In the plains stretches of the Ganga itself, it would be critical to examine the nature and extent of human induced modifications over at least the past 100 years, for which detailed written records are available.

Methods and recommendations The AHEC assessment report reviews at some length the existing methods being used for over three decades in various countries for estimating environmental flow requirements based on current science. They then dismiss their applicability summarily. Their cryptic explanation for this

1 Robin. L. Vannote et al: *The River Continuum Concept.* 1980. Can. J. Fish. Aquat. Sci. 37: 130-137.

rejection of methodologies used by other nations is that "they may be area-specific, and the same may not (be) used for Indian condition" and "keeping in view the water availability and water requirements in Indian basins". No further explanation, no science here either. Instead, they cherry-pick three elements from the very methodologies they reject, and put all three together in one single sentence as their recommendation. They recommend "the *minimum* flow given by the World Commission on Dams, *and* 75% of low flow based on Q95, *along with* the actual *minimum* required based on Environmental Management Class (EMC) and Hydraulic Mean Depth (HMD)" (the italics have been placed in this quote for emphasis only). Let us take a closer look.

The AHEC report reviews at some length the existing methods being used for over three decades in various countries for estimating e-flow requirements based on current science. They then dismiss their applicability summarily, without any scientific justification.

First, if you think that *and* and *along with* mean adding up, they don't. They are three different calculations to choose from, all three yielding the lowest flows of all methods in use elsewhere. Second, please notice that the 'optimum' flows of their earlier definitions quietly become 'minimum' flows. What minimum flow requirements mean for a hydro-power company is really maximum exploitation thresholds. Third, the authors of the AHEC report misrepresent the World Commission on Dams (WCD) as having prescribed 10% of Mean Annual Flows as environmental flows. WCD does not prescribe this. Q95 is the rate of flow in a stream that is exceeded 95% of the time, or 18 days of the lowest flows in a year. It is the very minimum, and in order to cope with this stress period, most adult fish and larger aquatic life-forms have to migrate down to larger stream volumes in order to survive. AHEC recommends that a further 25% may be abstracted out of this minimum, and provide for even further reduction when they say "along with actual EMC and HMD". Look closely, and you will see that they are actually ***three different ways that can be used either as per convenience, or in succession to reduce flow requirements further than the minimum environmental flow requirement that any country has arrived at so far.***

Environment Management Class The report outlines various ways for this. One of them, the EMC-FDC (Flow Duration Curve) method, is a grading based on an assessment of existing levels of modification & disturbance and subsequent biotic degradation in a river-stretch. You assign a river-stretch a class as per its environmental health-status, A to F in descending order[2]. The more the existing modification and worse the degradation class, the less water you need to allocate for environmental considerations. "The higher the EMC, the more water will need to be allocated for ecosystem maintenance or conservation, and more flow variability will need to be preserved."(7-23). Look at their tables that allot classes to various river-stretches, and you can see that ***wherever there is a hydro-project, which is the reason that stretch of river gets a lower grade in the first place, the smaller the percentage of Mean Annual Flows they need to allocate for the river's well-being.***

There is also lack of clarity in the assigning of EMC classes to stretches of the river. They mark them on the tables as EMC (biotic), which seems to refer to either their location on the epirhithronic, metarhithronic and hyporhithronic transitions (altitude zones for speed of flow and temperature), or their corresponding trophic levels. Here they are placed in EMC classes B, C and D. ***These can be zonation labels, and not grades to classify levels of modification, on the basis of which flow variability can be assigned***.

In other places they have gone into detail in defining EMC classes being assigned as per the disturbance levels in a river. They also take it another step towards obscurity when they say these classes are assigned by "expert opinion". The assessment needs to be absolutely clear about how they have gone about assigning environmental management classes, because this can be used by hydro-power companies in whichever context is useful to assign the least flows possible.

Hydraulic Mean Depth is used in this report to specify the minimum depth of water required to be left in the river in order to just keep alive the aquatic life-forms normally found in a river, in their words, "for their survival". They call these 'environmental flow requirements', and as per their own estimation, the minimum water requirement for benthic macro-invertebrates, fish, and otters is as follows: The basis for their assignment of depth and velocity for benthic macro-invertebrates (BMIs) is obscure. There is sufficient recent research on flow-modifications brought about by hydro-power projects to indicate that radical alterations in depth and velocity of water creates a transition in the dominance of BMI groups from palustrine (swiftly moving waters) to lacustrine (slow moving to stagnant waters) species[3]. This invariably leads to negative trophic cascades on predator species.

[2] A for rivers in a natural state with very minor modifications, to F for where the river ecosystem has been completely modified, with almost total loss of biota and habitat

[3] Daren Karlisle and others. Alteration of stream flow magnitudes and potential ecological consequences: A multiregional assessment. Front. Ecol. Environ. 2011, 9(5): pp 264-270.

Among the fish they recommend that snow-trout, barils and loaches need a mean depth of 20-30 cm (just shin deep water) with a flow velocity of 50-100 cm/ sec[4]. Catfish they say, need 15-20 cm depth (little more than ankle deep) in flow faster than 100 cm/ sec, and fish like mahseer, the largest cyprinid fish in the world, need a depth of just 30-50 cm (shin to knee deep) with a flow-velocity of 25-50 cm/ sec. The smooth-coated otter (*Lutrogale perspicillata*) the report says, will do just fine in 30-50 cm of water too, flowing at 25-50 cm/ sec. They've got their otter quite wrong[5], but even so, a typical family of smooth-coats, two parents and 4 pups, require among other habitat features, between 7-10 kilometers of deep unaltered stretch of river as territory in order to be able to get sufficient fish from[6] to survive. ***AHEC recommends knee to shin-deep water that will barely submerge an otter, let alone be habitat for enough fish for this apex predator of the mountain river-reaches. Otters, incidentally, are listed under schedule I of the Wildlife Protection Act of India, the highest protection category.***

So this is what you are left with when you take 10% of mean annual flows, reduce it to 75% of Q95 or the lowest-flows, and reduce it further again by grading river-stretches by EMC and punishing them further for having been degraded already by hydro-projects, and then give all life in the river an HMD or depth of water that even a zoo or an aquarium would not. This is done in a river where on an average, the natural rate of flow can be close to 500 cubic meters of water, every second.

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After recommending the above environmental flows, they have a major proviso (6-35). They say that "to evaluate the impact of HP on aquatic life much more detailed and quantitative data than available at present on the fauna and flora is required. Thus, at present *it is not possible to give any firm assessment on the impact of HP on the biodiversity* of the Alaknanda and the Bhagirathi basins. However, it is necessary to maintain the *minimum* environmental flows at each HP project to sustain the biodiversity of the rivers." If this is not a firm assessment of impact on biodiversity, how can it result in recommendations other than the use of the ***'precautionary principle',*** which is not to radically alter things we do not understand the impacts of. But no, they have now converted "*optimum*" flows to "*minimum*" flows and go ahead and recommend flows specifying depth, species-wise and in centimeters.

After recommending a range of options that yield the minimum possible flows, and then calling them environmental flows, the AHEC-IITR actually recommends the following: *"Modification or manipulation in morphology of stream channel in the form of increasing bed form, roughness, heterogeneity, and channel sinuosity is also recommended to improve habitat structure and induce hyporheic exchange flow in streams and rivers."* (See recommendation 12.4.14.) ***Is this science? Can anyone in AHEC-IITR please explain how this can be manipulated without ensuring flows that create such conditions? And with their recommending modifying channel sinuosity in Mountain Rivers, they just give themselves away.***

They also give themselves away repeatedly in the few specific recommendations they make. For example, they are clearly aware of the trickle that they have recommended because they further recommend that "in the diverted stretches of the river bed, at suitable intervals, about one meter high check dams may be constructed *where water would collect* to meet the needs of the local population." (Recommendation 12.6.4.17) One meter high for *water to collect*, in a river-bed where on average the flows are in hundreds of cubic meters every second!

They also recommend that *"no further allotments for hydro-power sites may be made for rivers where the percentage of river length affected is high. A threshold, say 70%, may be fixed for this purpose."* There is no analysis leading to this percentage, and no further explanation, no science. You think at first that they are saying "no" to further allotments where too many have already been done, but they are actually doing the inverse.

[4] The velocities mentioned here are within a normal range, but it would be impossible to get a combination of hydraulic mean depth and prescribed velocities for any length on a river-bed whose slope and bed-morphology are constantly changing.

[5] This is the habitat range of the Eurasian otter (*Lutra lutra*) and the small-clawed otter (*Aonyx cinerea*), neither of which find mention in their lists. The smooth-coated otter is essentially a plains animal that inhabit large and deep rivers and lake-habitats there. Ref. S.A. Hussain. Conservation status of otters in the terai and lower Himalaya of Uttar Pradesh, India. Proc VIIth International Otter Colloquium.

[6] S.A. Hussain and others in the IUCN Red List of Threatened Species.

What this "say 70%" really means for Himalayan Rivers is that you can "affect" an entire river from the point that it has sufficient flow to make commercial exploitation viable, all the way down. Most rivers originating at glaciers here have a flow of about only 1 cumec at the snout of the glacier, and it takes about a third of the length of a sub-basin, for 3rd and 4th order streams to build up sufficient flow to make hydro-power generation feasible at a commercial scale.

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But there is a clue where this "say 70%" might come from. If you look at AHEC's analysis of the likely modifications that will come about when the projects built, underway & planned in the two sub-basins are complete, it says that "about 31% of the Bhagirathi river length is diverted whereas 39% of the river is submerged." 70% see? They also say that "on the other hand, Alaknanda River may have 27% of the river length diverted & only 21% submerged". *Only*.

The report says that *"the endangered golden mahseer, which is migratory in nature will be adversely affected if any barrier which is more than 15 m in height is placed across their migratory route".* That is quite a leap. Of imagination. Ask a fisherman or a fish-scientist, and they would confirm that mahseer would find it impossible to get over a barrier ***even 2 m*** high. Mahseer are sometimes referred to as the elephants of fish; they can hardly jump. Why would AHEC say 15 m? It is not a random number. As per WCD, a dam higher than 15 m is a large dam. Should this report form the scientific basis for future cumulative impact assessment of hydro-projects, ***any dam below the height of 15 m could ignore their impact on mahseer migration altogether.*** This would include most dams on the smaller side-streams precisely where mahseer do go to spawn.

"Out of the 70 commissioned and under development projects, 54 are ROR type and 16 projects have substantial storage to regulate stream flows. It is clear that the *ROR projects will not have any impact on stream flows.*"(p. 7-66). They have also lumped all smaller projects (with pondage less than 20 m deep, and storage less than 10 million cubic meters is considered an ROR. Even "Kotlibhel 1A and 1B have *considerable* storage being used to provide head for the generation of power and there is little or no regulation of flows. Hence for the purpose of stream flow variability, this project is also considered an ROR project". They also found that "5 commissioned and under construction projects have *substantial* storage capacity to regulate incoming stream-flows. *This could be either beneficial or harmful*." Full stop, and no explanation. *Classic equivocation.*

On the question of ground water however, **they have chosen to ignore the most significant of alterations; the severe reduction of hyporheic (subsurface) flows under the river-bed and along the riparian zone and flood-plain areas.** Along the Bhagirathi main stem 31% of the river sections will be diverted into tunnels, and here, sub-surface flows will be greatly reduced due to the greatly reduced above-ground flows. Their recommendation for e-flow requirements do not take this into consideration at all. This vertical and lateral connectivity is entirely ignored in their recommendation, even though they have given lip service to its importance in their preambles.

On ground water and springs (7-108) While the report says it does not have enough data on this matter and that "it may be difficult (or improper) to conclude with confidence on the impact of construction of hydro-projects on the availability of groundwater and drinking water sources to the population in the project area" they still go ahead and say "due to construction of a dam... it is expected that there would be a positive impact of project for groundwater recharge and availability", and then go on to say "It may be noted, that due to the construction of tunnels it is expected that the discharge of a few springs may reduce but at the same time the discharge of a few springs may increase. It appears that the overall impact may be the *redistribution of the flow*"! Redistribution? There is repeated evidence at very many villages, wherever there has been tunneling below them, that due to the great quantities of explosive used for blasting tunnels, the impermeable layer that causes sub-surface flows to emerge as springs to the surface get shattered underneath, leading to the spring percolating through the cracks and disappearing from the surface. People have located their villages hundreds of years ago, on the basis of spring water availability and potentially arable land at particular locations. If it gets 'redistributed' a few km down slope, I guess they should just shrug and relocate their entire village and their agriculture fields to this new location.

The AHEC-IITR assessment also says that "periodic high flushing flows are desirable to prevent settling of fine, clogging interstitial spaces in the substratum" (7-105). They themselves also say on the other hand, that "normally the flushing is carried out once every year. *Flushing is not very environmentally friendly because a large amount of accumulated sediment is released during a short period when the natural flow may be smaller and this may cause environmental problems in the downstream areas*." It is precisely these flushing flows that have been listed as extremely harmful in all the studies that have been conducted on the impacts of hydro-power projects.

The report also recommends that "Fish passes may be made an integral part of hydro-power projects". By saying this they have put away the problem and given the go-ahead for the hydro-projects. Surely the good engineers knew that building a fish pass or ladder more than 15 m high has not been feasible so far?

Protected Areas Rivers in India are not protected under law, except in areas that fall within Protected Areas such as Wildlife Sanctuaries and National parks. The report contains a sub-title 'Forest and protected Areas' (6.13). Under this title is a whole three sentences. "The basin is home to a number of protected areas and reserve forests. These areas and hydro-power projects are shown in Fig. 6.12. *It can be seen that seven projects are located in the protected areas."* ***This is all they have to say regarding the impact of hydro-projects on river-stretches that are within Protected Areas. A Protected Area seeks to protect life-forms and habitats in the terrestrial and aquatic realms and their transitions, and the cumulative impact of the incremental reduction of these habitats bears serious consideration. This has been ignored.***

People have located their villages hundreds of years ago, on the basis of spring water availability & potentially arable land. If it gets *'redistributed'* a few km down-slope due to a project, are they to simply relocate their village & fields to this new location? … The nation deserves better science, & not a trojan-horse bearing short-sighted commercial interests.

Finally, despite all their protestations that "the development of hydro-power projects should be based on *scientific facts* and not started or stopped due to pressures/lobbying by individuals/groups", the concluding statement of the AHEC-IITR report on the issue of environmental flows is: "Environmental Flow Requirement depends on development stage of the area and societal requirement …" Whatever happened to *scientific facts* along the way?

Finally, the ultimate decision on how we use our rivers and how much, will be negotiated in the political realm. But there is a need for a more honest science here. While the AHEC-IITR report uses the language of science and reproduces lengthy reviews of scientific method, ***in all the critical aspects such as cumulative assessment of impacts and recommending e-flows, science and precision are seriously lacking.***

Conclusions and Recommendations They have 14 conclusions regarding the **cumulative impact**. Of these, three have been listed to be positive (tourism, irrigation and the economy). Five have been listed as having nil or insignificant impacts (seismicity, glaciers, religious places, water quality in storage dams and water quality in ROR projects). The remaining 6 impacts are slope stability, loss of spring water, sedimentation, dumping of muck, fish passage, by-passed sections of the river going dry. It is appropriate to note that all this amount to a big nod.

They have **42 recommendations.** Of these 17 points relate to those which need to be researched in more detail, monitored more closely or implemented with more care. Then there are 9 points that relate to religious and social aspects where more care needs to be taken. Then is a list of inane and contradictory recommendations. Their first conclusion is that "the impact of hydro-power projects on seismicity is nil". That such projects do not induce earthquakes. However in their recommendation number 7 they say that hydro-projects more than 20 m high, especially close to the Main Central Thrust may be avoided, and if not avoided, then monitored. There is also no consideration to the seismic impact of thousands and tonnes of explosives being used to blast kilometers of tunnels. Even if they do not induce earthquakes, the incremental damage likely to be caused is entirely ignored.

Regarding flows, after recommending flows in centimeters, they revert to the cover-up of words that say **'optimum flows should be released, variation of flow must be maintained, the very harmful flushing should be resorted to, unthinkable channel modification should be undertaken, fish passes should be made, banks should be reforested, and 70% of a river length can be modified.** They also recommend that 1 m high dams be made on the river bed where rivers are diverted, and round it off with ***a general statement that there should be a gap between hydro-projects, enough for the river to 'recover itself'. What this gap should be, & what are the parameters of recovery are of course not stated***.

Is it a mere coincidence then that AHEC-IITR's own professed competence really lies in turbine design & hydro-power plant efficiency? Or that they have standing memoranda of understanding with state govts of *all* the West Himalayan states for the development of hydro-power (including Uttarakhand where they conducted the study in question), and that their recruiters are the biggest hydro-power companies in the country (see: http://ahec.org.in/)? **If this AHEC-IITR report is accepted by govt as the template for assessments of cumulative impacts of hydro-power projects in India, we will take the life out of our rivers, and much more. The nation deserves better science, & not a trojan-horse bearing short-sighted commercial interests.**

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